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An Apparent Influence of the Earth on the Numbers and Areas of Sun-spots in the Cycle 1889–1901. By A. S. D. Maunder.

(*Communicated by Sir W. H. M. Christie, K.C.B., Astronomer Royal.*)

1. *Introductory.*

The material used in the following paper is derived from the Photo-heliographic Results published by the Astronomer Royal in the Greenwich Observations from the years 1889–1901 inclusive. During these years the results of the measures made at Greenwich of photographs of the Sun, taken daily at Greenwich, in India, and in Mauritius, are exhibited in two chief forms. In the first, the measures of positions and areas of sun-spots are given day by day. In the second, they are arranged in the form of "Ledgers" of the groups of spots, and it is these ledgers which I have utilised for the present inquiry. These ledgers of the spot groups were first given for the year 1886, but as a complete cycle of spot activity ran its course during the years 1889–1901, I have confined my present investigation to those thirteen years. The Astronomer Royal, in his last Report to the Board of Visitors, has announced that he is having similar ledgers prepared for the years 1874–1885, and when these appear I hope to treat the cycle 1878–1889 in the same way as I have here treated the cycle which followed it.

The object of my inquiry is to ascertain whether these measures of the solar photographs afford any support to the idea that the Earth exercises, or seems to exercise, any perceptible influence, either on the numbers or on the areas of the spot groups.

The following is a sample of one of the sun-spot ledgers:—

TABLE I.

Extract from Ledger of Sun-spots.

Group 5104.

A very fine stream following Group 5103. The stream is so compact that it is frequently measured as consisting chiefly of one very large composite spot. By November 13, two very large spots, *a* and *b*, have formed at the front and rear of the group respectively.

Date. Greenwich Civil Time.	Projected Area of		Area for Group.		Mean Longitude of Group.	Mean Latitude of Group.	Longitude from Central Meridian.
	Umbra.	Whole Spot.	Umbra.	Whole Spot.			
Nov. 4·515	17	164	59	561	168·9	−23·8	−79·0
5·452	64	458	105	752	166·8	−24·1	−68·7
6·531	92	764	96	809	164·8	−24·3	−56·6
7·466	109	1150	88	925	164·3	−24·2	−44·8
8·225	124	1274	86	879	162·8	−24·5	−36·2
9·526	210	1471	125	882	163·3	−24·4	−18·6
10·265	213	1349	122	775	163·0	−24·5	− 9·1
11·194	193	1356	109	771	163·8	−24·9	+ 4·0
12·146	233	1389	139	828	163·1	−25·3	+15·7
13·195	192	1163	126	767	163·4	−25·1	+29·9
14·561	78	682	70	588	163·9	−25·0	+48·4
15·154	96	463	102	483	164·2	−25·0	+56·5
16·228	47	266	88	462	163·7	−24·8	+70·2
17·298	3	37	12	132	159·7	−25·0	+80·2
Means ...	...	...	95	687	163·98	−24·64	...

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The several columns of the ledger are described in the Introduction to the Greenwich Observations.

Spots, brought into view by the rotation of the Sun on its axis, are first seen at the east limb, and pass out of view at the west limb; the longitudes from the central meridian given in the eighth column being reckoned as negative when the spots are east of the central meridian and positive when they are west.

In the following discussion, the data of which I make use are those given in the fifth and eighth columns respectively, that is to say, the areas (expressed in millionths of the Sun's visible hemisphere, and corrected for foreshortening) of the whole spots, and the longitudes of the groups as reckoned from the central meridian of the Sun.

The period of rotation assumed for the Sun in the Greenwich Photo-heliographic Results is 25·38 days. This is, of course, the siderial period of rotation; the corresponding mean synodic rotation is 27·275 days, and the mean apparent daily motion of a spot with respect to the central meridian will be 13°·2. A long-lived spot will appear to cross the visible disc of the Sun in thirteen or fourteen days. I have therefore, for the purpose of this investigation, divided the Sun's visible hemisphere into fourteen lunes, of which seven are east of the central meridian and seven are west, each lune being 13°·2 of longitude in breadth. In the lune corresponding to the "Longitude from the Central Meridian" for each day of apparition of a spot group, I have entered the area of the spot group, corrected for the effect of foreshortening, for that day. For example, the spot group already cited would be entered as on Table II.

2. *Preponderance of Areas of Sun-spots in the Eastern Hemisphere.*[*]

In all, 2870 spot groups have been thus treated, the total number of entries being 15,721, for few of the groups were observed for fourteen days, the average duration being about six days. Table III. gives the result of summing up the total areas for each lune, first, for the northern hemisphere, and then for the southern, and thirdly for the entire disc of the Sun.

It will be seen that in both hemispheres there is a regular progression in the spotted area from the first lune to the seventh, and a corresponding decrease from the eighth lune to the fourteenth.

The areas in the first and in the fourteenth lunes are much smaller than those in the remaining twelve. The reason for this is obvious. A spot is practically invisible when it is distant 86° from the central meridian. The effective breadth, therefore, of the first and last lunes is only half that of any of the remaining twelve. It must also be borne in mind that spot groups in general extend over several degrees of longitude, so that the centre of a group may

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[*] Strictly speaking, this is only a quarter of the sphere, but it seems unnecessarily pedantic to coin a new term.

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TABLE II.

Extract from the Form for entering the Areas in the Lunes.

Date when first seen.	No. of Group.	1st Lune. −79°·3 and over.	2nd Lune. −66°·1 to −79°·2	3rd Lune. −52°·9 to −66°·0	4th Lune. −39°·7 to −52°·8	5th Lune. −26°·5 to −39°·6	6th Lune. −13°·3 to −26°·4	7th Lune. − 0°·1 to −13°·2	8th Lune. + 0°·1 to +13°·2	9th Lune. +13°·3 to +26°·4	10th Lune. +26°·5 to +39°·6	11th Lune. +39°·7 to +52°·8	12th Lune. +52°·9 to +66°·0	13th Lune. +66°·1 to +79°·2	14th Lune. +79°·3 and over.	Total Area of Group.	Mean Hel. Long. of Group.	Mean Hel. Lat. of Group.
1903. 11.4	5104	561	752	809	925	879	882	775	771	828	767	588	483	462	132	9614	164°	−25°

TABLE III.

Lunes.

Eastern Hemisphere. Western Hemisphere.	1st −79°·3 and over. 14th +79°·3 and over.	2nd −66°·1 to −79°·2 13th +66°·1 to +79°·2	3rd −52°·9 to −66°·0 12th +52°·9 to +66°·0	4th −39°·7 to −52°·8 11th +39°·7 to +52°·8	5th −26°·5 to −39°·6 10th +26°·5 to +39°·6	6th −13°·3 to −26°·4 9th +13°·3 to +26°·4	7th − 0°·1 to −13°·2 8th + 0°·1 to +13°·2	Eastern Hemisphere. Western Hemisphere.
Northern Spots.								
East.	24358	74826	89979	99224	102708	105138	106216	602449
West.	21302	71476	87947	93799	100949	103883	104679	584035
Difference E. − W.	+3056	+3350	+2032	+5425	+1759	+1255	+1537	+18414
Southern Spots.								
East.	35622	95195	111741	119763	125225	128292	128995	744833
West.	27370	90480	108816	117282	124169	128585	129869	726571
Difference E. − W.	+8252	+4715	+2925	+2481	+1056	−293	−874	+18262
All Spots.								
East.	59980	170021	201720	218987	227933	233430	235211	1347282
West.	48672	161956	196763	211081	225118	232468	234548	1310606
Difference E. − W.	+11308	+8065	+4957	+7906	+2815	+962	+663	+36676

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fall within the first or last lune, though much of its area may be actually beyond the visible hemisphere. The areas in these two lunes ought therefore to be multiplied by some factor greater than 2, to make them really comparable with the other twelve.

But omitting these two lunes, we yet see a very marked progression in the other twelve; the areas steadily increase from the east to the central meridian, and diminish from the central meridian to the west.

What can be the cause of this? Two suggestions immediately present themselves. There may be some systematic error in the measurement, or there may be some systematic error in the reduction.

There are several causes which can be conceived as possibly giving rise to an error of the second kind. First of all the intense brightness of the Sun may, by irradiation, make the photographic radius systematically appear greater than it really is, with the result that the distance of the spot from the centre of the disc, expressed in terms of the radius, will be too small. An effect in the same direction would also arise from the measurer judging the centre of the spot as if he were dealing with a marking on a plane surface. This again would tend to put the position of the centre of the spot slightly too near the centre of the disc, since the effect of foreshortening will always be greatest on the side of the spot furthest from the centre. Yet again, if there is any sensible displacement of the position of a spot due to the effect of refraction in the solar atmosphere, this would also make the spot appear nearer the centre of the disc than it really is. The effect of each of these hypothetical sources of error in the measurement would be the same; the distance of a spot from the centre would be under-estimated, and too small a correction would be applied for foreshortening, and as the factor increases with the sine of the angular distance from the centre, the areas of the lunes near the limb would require to be increased in a higher proportion than those near the centre.

If the steady progression from the east limb to the central meridian, and from the central meridian to the west limb, were the only feature shown by Table III., it would be necessary to examine very carefully in detail each of the above hypothetical sources of error, trivial though they certainly must be. But there is another feature, just as clearly shown, into which any error in the correction for foreshortening cannot enter. If we compare the area of the eastern hemisphere with the area of the western, we find that the eastern is always the greater, whether we consider the north or the south. And further, if we compare each of the several lunes in the eastern hemisphere with the corresponding lune in the western, we find that, almost without exception, the eastern is the greater, usually much the greater.

This difference between the two hemispheres cannot be due to any error of foreshortening, seeing that the hemispheres and their constituent lunes are symmetrical. Neither can it be due to any personal equation in the measurement of the solar photographs;

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the form of the micrometer and the method of measuring preclude that. (See Introduction to Greenwich Observations.)

The amount of the predominance of the areas in the eastern hemisphere over those in the western is too marked, both for the hemispheres as a whole, and for their constituent lunes, for it to be accidental, whatever explanation may be assigned for it.

3. *Preponderance of Numbers of Spot Groups in the Eastern Hemisphere.*

There is a simple way of getting rid of any systematic error in the measurement or reduction of the areas of the spots; *i.e.*, we may discard the areas and deal only with the number of groups. This is what has been done in Tables V. and VI. following. It will be observed that not only are the total numbers of groups counted in each lune given, but the groups are arranged in classes. All spots do not live for the same length of time. They may come into existence on the invisible hemisphere of the Sun, or on the visible hemisphere; and similarly, they may die out either on the invisible or on the visible hemisphere. They may be seen for one, two, or any number of consecutive days up to fourteen. If very long-lived, they may be so seen in a second, third, fourth, or even in a fifth rotation, but in this discussion I have treated each apparition of a spot group as a separate and independent display, except where the contrary is expressly stated. Regarding, therefore, fourteen days as the longest period for which a spot group can be followed consecutively, I have thought it well to divide the whole cycle of the sun-spots of 1889–1901 not only into those in the northern and southern hemispheres of the Sun respectively, but also into classes distinguished by the number of days during which the group was visible; that is to say, into classes of spots observed for fourteen consecutive days, for thirteen, for twelve, and so on, down to ephemeral groups which were observed only upon a single day. On the average, I found that the mean area of a group bore a direct proportion to the length of time for which it was visible. The following Table IV. gives the number of groups which existed for each of the given periods, the total area of the groups, and the mean area per group. Here it may be noted that both the number of groups and the mean area per group are slightly greater in the southern than in the northern hemisphere.

In Table V. the third section of Table IV. is dealt with, but the totals for each lune in the northern and southern hemispheres separately are added at the foot. The spots are not only divided into classes according to the length of time that they were under observation, but each lune is treated separately, and the number of groups observed in that particular lune is recorded. The total numbers observed in the eastern and western hemispheres are likewise exhibited.

From the nature of the case, the number of spots of the first class, namely, those observed for fourteen days, is the same for all

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TABLE IV.

Total Areas and Mean Areas of Groups of Different Durations.

No. of Days.	Northern Spots. No. of Groups.	Northern Spots. Total Area.	Northern Spots. Mean Area. Per Day.	Southern Spots. No. of Groups.	Southern Spots. Total Area.	Southern Spots. Mean Area. Per Day.	All Spots. No. of Groups.	All Spots. Total Area.	All Spots. Mean Area. Per Day.
14	10	55893	399	21	184142	626	31	240035	553
13	100	455948	351	99	477671	371	199	933619	361
12	93	291688	261	108	343318	265	201	635006	264
11	57	116564	186	66	129800	179	123	246364	182
10	54	65709	122	69	93245	135	123	158954	130
9	62	55491	99	61	53414	97	123	108905	98
8	61	45504	93	84	56715	84	145	102219	88
7	55	30602	80	73	41870	82	128	72472	81
6	65	17564	45	80	28300	59	145	45864	53
5	73	20919	57	85	17319	41	158	38238	48
4	88	12358	35	133	23228	44	221	35586	40
3	98	7724	26	113	11560	34	211	19284	30
2	135	6336	23	168	6169	18	303	12505	21
1	349	4184	12	410	4653	11	759	8837	12
Total,	1300	1186484	165	1570	1471404	172	2870	2657888	169

TABLE V.

Number of Groups in each Lune for each Class of Duration of Spot Groups.

No. of Days.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	E.	W.	E.-W.
14	31	31	31	31	31	31	31	31	31	31	31	31	31	31	217	217	0
13	109	199	199	199	199	199	199	199	199	199	199	199	199	90	1303	1284	+ 19
12	33	186	201	201	201	201	201	201	201	201	201	201	168	15	1224	1188	+ 36
11	18	82	116	123	123	123	123	123	123	123	123	105	41	7	708	645	+ 63
10	16	63	82	112	123	123	123	123	123	123	107	60	41	11	642	588	+ 54
9	12	52	70	93	114	123	123	123	123	111	71	53	30	9	587	520	+ 67
8	15	67	86	96	110	137	145	145	130	78	59	49	35	8	656	504	+152
7	8	40	61	64	77	94	124	120	88	67	64	51	34	4	468	428	+ 40
6	3	39	64	81	88	96	110	102	81	64	57	49	32	4	481	389	+ 92
5	9	42	59	68	84	84	66	67	82	74	65	50	32	8	412	378	+ 34
4	9	47	77	104	107	83	76	69	71	83	68	48	34	8	503	381	+122
3	2	33	58	71	53	40	52	58	63	55	59	50	31	8	309	324	− 15
2	0	30	59	51	43	56	66	54	49	52	50	55	36	5	305	301	+ 4
1	1	35	64	66	65	73	94	94	83	64	50	37	28	5	398	361	+ 37
Total,	266	946	1227	1360	1418	1463	1533	1509	1447	1325	1204	1038	772	213	8213	7508	+705
North,	124	428	563	625	636	661	697	682	655	617	560	474	349	103	3734	3440	+294
South,	142	518	664	735	782	802	836	827	792	708	644	564	423	110	4479	4068	+411

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lunes. For the second class, those observed for thirteen days, the number is the same for each lune except the first and last. Similarly for the successive classes, until we come to spots observed for less than half a complete transit, that is to say, for seven days and under. For the spots of long duration, therefore, the number of spots observed in each lune near the centre of the disc must necessarily be constant. But when we exclude these, it will be noted that not only do the numbers in the whole of the eastern quadrant exceed those in the whole of the western in nearly every case, but in most instances the number in any particular eastern lune exceeds that in the corresponding western lune.

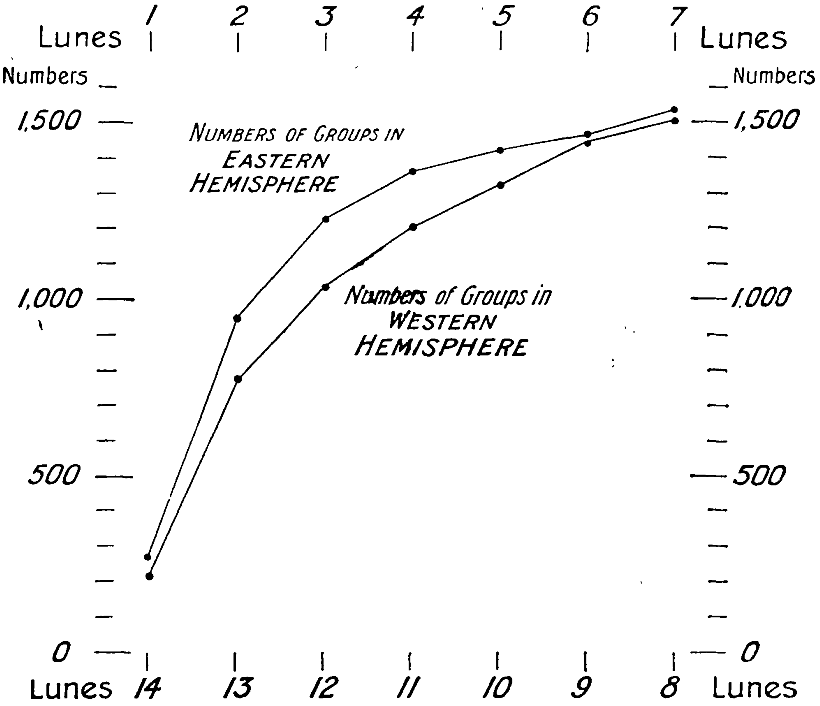

FIG. 1.—Numbers of Groups in each Lune, comparing East and West.

Table VI. (represented graphically in fig. 1) gives the differences in the number of groups between the corresponding eastern and western limbs, regardless of the class of the spot, that is to say, of the length of time that it was under observation. It will be seen that both for the northern spots and for the southern, and consequently for the two combined, the eastern lune always shows an excess over the corresponding western lune as to the number of spots observed. In no single case does the number of groups in a western lune equal those in the corresponding eastern one. The preponderance of east over west attains its maximum in the third lune from the limb, where the proportion is almost exactly 7 to 6.

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TABLE VI.

Differences in Numbers of Groups found in Corresponding Lunes, E.–W., for Northern, Southern, and All Spots.

	1–14	2–13	3–12	4–11	5–10	6–9	7–8	E.-W.
Northern,	+21	+ 79	+ 89	+ 65	+19	+ 6	+15	+294
Southern,	+32	+ 95	+100	+ 91	+74	+10	+ 9	+411
All Spots,	+53	+174	+189	+156	+93	+16	+24	+705

4. *Preponderance of Numbers of Spot Groups rising in the Unseen Hemisphere.*

It has already been shown that the eastern hemisphere has a systematic preponderance over the western hemisphere in respect both to total spotted area and the numbers of spot groups. The question naturally arises, Can we ascertain whether there is any difference between the visible and invisible hemispheres in respect to the numbers of groups, and, if so, which hemisphere has the advantage?

Something can be learnt from the comparison of the numbers of groups seen in the two lunes nearest to the east limb on the one side, with those given by the two lunes nearest to the west limb. For, from the nature of the case, these numbers most nearly represent the number of groups which come round into view from the unseen hemisphere on the one side, and pass away into it on the other.

TABLE VII.

Numbers of Groups seen in the First or Second Lune, and in the Thirteenth or Fourteenth Lune, with their differences, for Northern, Southern, and all Spots.

	North.			South.			Whole Sun's Disc.		
No. of Days.	1st or 2nd Lune.	13th or 14th Lune.	Diff. E.-W.	1st or 2nd Lune.	13th or 14th Lune.	Diff. E.-W.	1st or 2nd Lune.	13th or 14th Lune.	Diff. E.-W.
14	10	10	0	21	21	0	31	31	0
13	100	100	0	99	99	0	199	199	0
12	85	79	+ 6	101	89	+12	186	168	+ 18
12	34	23	+11	48	18	+30	82	41	+ 41
10	33	12	+21	30	29	+ 1	63	41	+ 22
9	27	13	+14	25	17	+ 8	52	30	+ 22
8	26	14	+12	41	21	+20	67	35	+ 32
7	20	13	+ 7	20	21	− 1	40	34	+ 6
6	16	15	+ 1	23	17	+ 6	39	32	+ 7
5	21	18	+ 3	21	14	+ 7	42	32	+ 10
4	22	14	+ 8	25	20	+ 5	47	34	+ 13
3	16	12	+ 4	17	19	− 2	33	31	+ 2
2	9	16	− 7	21	20	+ 1	30	36	− 6
1	10	13	− 3	26	20	+ 6	36	33	+ 3
Total,	429	352	+77	518	425	+93	947	777	+170

This comparison is brought out in Table VII. where, as in Tables IV and V., the numbers are given for northern and southern spots

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separately and combined, and for all classes of spots. With very few exceptions, the number of groups that come into view out of the hemisphere that is remote from the Earth exceeds that of the groups that pass out of sight from our Earth into the unseen hemisphere. It is further significant that the exceptions are almost entirely confined to spots of very short duration, not exceeding three days.

Now this persistent preponderance cannot be a mere chance effect; the signs in the third columns are too constantly positive for anything that is purely accidental. Yet the eastern and western lunes have no significance at all, when considered from a standpoint on the *Sun*; their distinctiveness lies in their different relations to the *Earth.* Putting the matter shortly, we see that, in all, 947 spot groups came round the eastern limb of the Sun into view of the Earth, and only 777 passed round from the view of the Earth at the western limb into the invisible hemisphere. And whether we consider the Sun as a whole, or its northern and southern hemispheres separately; or whether we consider the spot groups with or without regard to their length of life, we get a result to the same effect. We are driven to conclude that during the cycle, 1889–1901, the Earth was apparently responsible for the extinction of about 170 spot groups; that is to say, of more than one-sixth of the whole number that came into view round the eastern limb. Whether this effect was produced by bringing about the premature dissolution of old groups, or by hindering the generation of new groups, or by a combination of the two, there is no doubt as to the magnitude of the resulting effect.

5. *Birth-rate and Death-rate of Spot Groups in the Different Lunes.*

It will be interesting to examine whether there is any tendency for spots to take their origin in one lune rather than another, and also whether certain lunes are especially favourable for their dissolution. It is manifest that the fact that a spot is first seen in lunes 1 and 2 affords very small evidence that it actually arose in those lunes; the strong probability is that it arose in the unseen hemisphere. Similarly, the fact that a spot is last seen in either lune 13 or 14, affords no presumption that its actual dissolution took place there. But when we are dealing with the ten central lunes we have a certain amount of positive evidence that the groups first seen or last seen in these regions of the disc were not visible earlier or later. The effect of foreshortening will no doubt be to hide a few of the smaller groups, whilst in the two lunes nearest to either limb, and in a few quite accidental cases, this may even extend to the third lune from each limb; but the record of appearances and disappearances for at least the central lunes must be substantially correct.

Table VIII., which may be considered as a supplement to Table VII., gives the number of groups first seen in each lune from the 3rd to the 12th inclusive, and also the number of those last seen.

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Ephemeral spots, that is those only seen on a single day, are not included in this table.

TABLE VIII.

Numbers of Groups first seen or last seen in the Ten Central Lunes.

Lune.	First Seen.			Last Seen.		
	North.	South.	All Spots.	North.	South.	All Spots.
3	113	139	252	10	22	32
4	72	91	163	33	36	69
5	50	78	128	39	55	94
6	54	77	131	45	57	102
7	70	81	151	62	74	136
8	47	65	112	61	75	136
9	41	44	85	66	116	182
10	39	40	79	80	82	162
11	27	28	55	100	92	192
12	17	22	39	116	146	262
Total,	530	665	1195	612	755	1367

Since the 3rd lune is symmetrical with the 12th, the 4th with the 11th, and so on, any error, from such effects of foreshortening, in the number of spots first seen in the 3rd lune, will be of the same amount as that in the number of spots last seen in the 12th lune; and so with the other pairs of corresponding lunes. The difference, therefore, ought to be free from any such effect of foreshortening, and to represent not an apparent effect but a real difference.

Table IX. is derived from Table VIII., and exhibits the differences in the number of groups first seen in any particular lune, with the number last seen in the corresponding lune.

TABLE IX.

Comparison of Numbers of Groups first seen in any Lune with those last seen in the Corresponding Lune.

Seen					
first in Lune.		last in Lune.	North.	South.	All Spots.
3	–	12	− 3	− 7	− 10
4	–	11	− 28	− 1	− 29
5	–	10	− 30	− 4	− 34
6	–	9	− 12	− 39	− 51
7	–	8	+ 9	+ 6	+ 15
8	–	7	− 15	− 9	− 24
9	–	6	− 4	− 13	− 17
10	–	5	− 0	− 15	− 15
11	–	4	− 6	− 8	− 14
12	–	3	+ 7	− 0	+ 7
Totals,			− 82	− 90	− 172

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From Table IX., therefore, we see that there is an average excess per lune of 17 dissolutions over formations; this being made up of 8 in the northern hemisphere and 9 in the southern, which is very nearly in the proportion of the total number of groups of either hemisphere. For every 7 groups that form on the visible disc, 8 dissolve, or at least one-seventh more groups form on the invisible hemisphere than on the visible. The death-rate on the visible hemisphere is systematically higher than the birth-rate.

When we deal with the distribution of the ephemeral spots (see Table V.), we find a steady increase in number per lune from the east to the central meridian, and a decrease thence to the west limb. But the ratio of those generated on the eastern side to those generated on the western is about 11 to 10, being an excess of 37 in a total number of 755.

In Table III. a comparison was made between the total spotted area shown by the eastern and western hemispheres, the area of the former being 1347282 and of the latter 1310606 millionths of the Sun's visible hemisphere; the excess of the eastern hemisphere was thus 2·8 per cent. In Table VII., in which the number of groups in the two most easterly lunes were compared with those in the two most westerly, the excess of the easterly amounted to 21·9 per cent. In Table V., where the groups seen in each lune were summed up together, the preponderance of the eastern hemisphere was 9·4 per cent. In Table V. the ephemeral groups show a preponderance in the eastern hemisphere of 10·3 per cent. over the western; whilst the number of dissolutions given in Table VIII. shows a predominance over the formations of 14·3 per cent. It will be seen that, though the predominance of the eastern hemisphere over the western in the matter of area is well marked and consistent, yet that it is by no means so great in proportion as is the predominance in the number of groups. This would appear to indicate that, whatever was the cause of the predominance of the eastern hemisphere, it was one which affected small groups to a greater degree than large ones. But if we group the areas in the same way as we have already grouped the numbers, we shall see the introduction of another factor which will render the last inference more clear.

6. "*Spot Phase.*"

In Tables X. and XI. the total areas are given for each lune, but the spots of the different classes are exhibited separately. Both tables are for the whole disc of the Sun; but in Table XI. and in fig. 2 the areas are expressed, not in millionths of the Sun's visible hemisphere, but each class of spot has been taken separately, and the area of each lune has been expressed in thousandths of the total area for that class. These present the remarkable feature that the maximum area for any class of spot tends to shift over from the east towards the west as we go from the spots of long duration to those of short.

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TABLE X.*

TABLE XI.

Areas for each Lune for All Spots of Different Durations.

Total.

No. of Days.	1	2	3	4		6	7	8	9	10	11	12	13	14	East.	West.
14	10381	18467	20883	21621	21781	21302	19590	19180	17880	16592	16705	15560	12628	7465	134025	106010
13	31116	65321	74909	81254	82086	81353	80459	77608	76474	73221	66456	61456	53382	22061	496498	430658
12	7699	43536	53858	56202	56298	57587	58412	57634	56075	53523	49667	44913	34832	4770	333592	301414
11	3367	12654	15503	18508	22917	25568	25599	24859	24167	22255	18438	16013	10858	1607	124116	118197
10	2007	7142	8652	11634	13786	15441	16412	16487	16214	14597	13549	11611	9414	2008	75074	83880
9	1429	5936	6538	7984	9917	11488	11627	10768	9952	9990	8049	7272	5523	2254	54919	53808
8	1898	6169	7024	6985	6942	7558	7962	10046	10638	10494	9878	8837	6428	1360	44538	57681
7	946	2927	3596	3650	3905	4047	5264	7278	8491	8900	8638	8022	5826	719	24335	47874
6	163	2112	2630	2845	2629	2155	2362	3189	4889	5415	5514	6178	5150	486	14896	30821
5	469	1584	2125	1994	1835	1654	1773	2323	2816	3496	4646	5756	5609	1841	11434	26487
4	417	1844	2234	2562	2311	1731	1769	1466	1533	2988	4688	5149	5097	1797	12868	22718
3	64	984	1469	1278	1089	722	956	1008	1032	1151	2075	3199	3042	1071	6562	12578
2	0	592	888	791	569	813	823	858	543	861	1071	1368	2787	624	4476	8112
1	13	427	719	727	610	737	916	727	681	673	611	583	909	503	4149	4687

Expressed in Thousandths.

No. of Days.	1	2	3	4		6	7	8	9	10	11	12	13	14	East.	West.
14	43	77	87	90	91	89	82	80	74	69	70	65	53	31	558	442
13	34	70	81	88	89	88	87	84	82	79	72	66	58	24	536	464
12	12	69	85	88	89	91	92	91	88	84	78	71	55	8	525	475
11	14	52	64	76	95	106	106	103	100	92	76	66	45	7	512	488
10	13	45	54	73	87	97	103	104	102	92	85	73	59	13	472	528
9	13	54	60	73	91	105	107	99	91	92	74	67	51	21	505	495
8	19	61	69	68	68	74	78	99	104	103	97	87	63	13	435	565
7	13	41	50	51	54	56	73	101	118	123	120	111	81	10	337	663
6	4	46	58	62	58	47	52	70	107	118	121	135	113	11	326	674
5	12	42	56	53	48	44	47	61	74	92	122	152	148	49	301	699
4	12	52	63	72	65	49	50	41	43	84	132	145	143	51	362	638
3	3	52	77	67	57	48	50	53	54	60	109	167	159	56	343	657
2	0	47	71	63	45	65	65	68	43	68	85	109	221	50	356	644
1	3	48	81	82	69	83	104	82	77	76	69	66	103	57	470	530
Total,	23	64	76	82	86	88	88	88	87	85	79	74	61	18	507	493

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* There is a slight difference in the material employed in Tables III. and X. Table III. embraces all spots of the cycle 1889–1901, whilst Table X. does not extend beyond the end of 1900.

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The curves given by the 14- and 13-day spots are somewhat flat, and come to a maximum on the fifth day. The curve continues to be very flat for the 12-day spots, but the maximum is shifted to the seventh lune. The 11-day spots show a more decided curve, and by the time the 8-day spots are reached the maximum is found in the ninth lune. The 6-day spots show two maxima, a small one in the fourth lune and a much greater in the twelfth. The spots of 5-, 4-, and 3-day duration give curves of the same form, but with the two maxima more and more accentuated. The 2-day groups show a tremendous peak in the thirteenth lune, beside two small maxima, the one in the third lune and the other at the centre of the disc. The ephemeral spots also have three maxima,

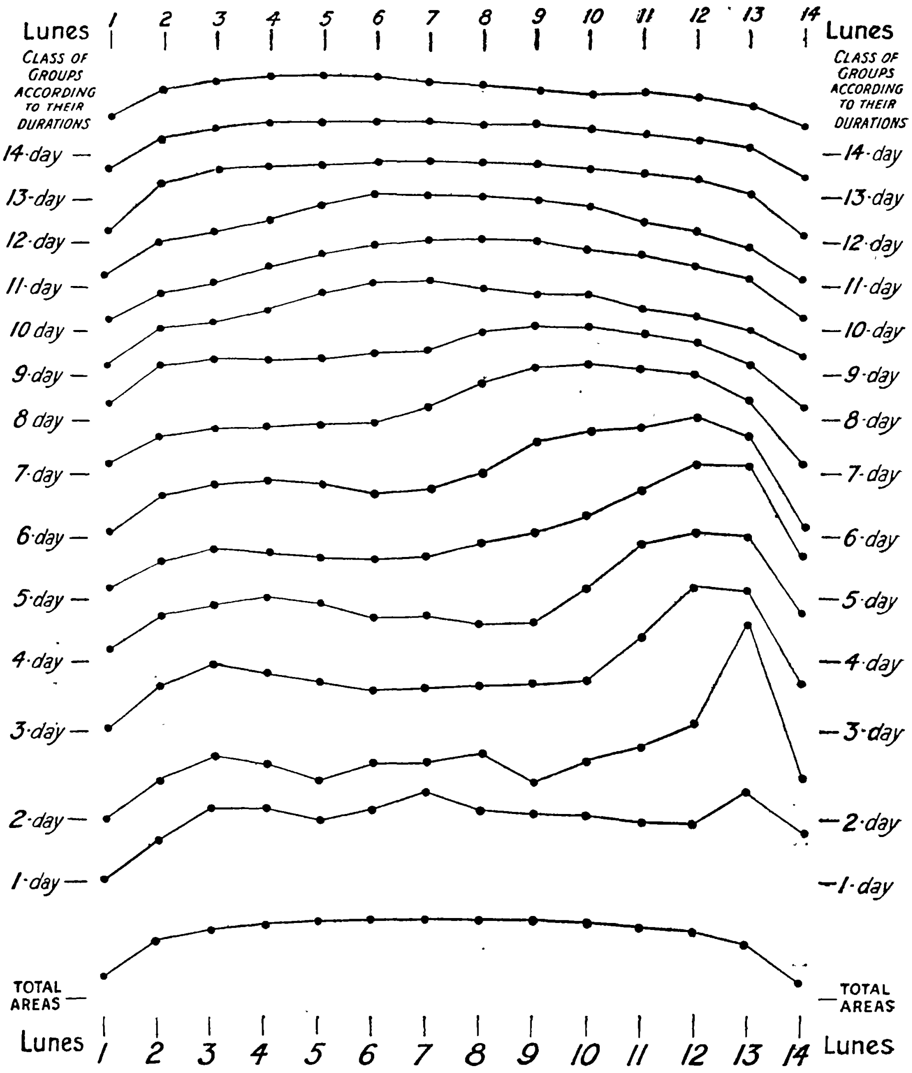

Fig. 2.—Curves of the Variation in Area for Spots of different Durations as seen in the different Lunes.
(The areas are expressed in thousandths of the total area for each class.)

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one in the fourth lune, one in the seventh, and one in the thirteenth. The total areas of all spots, irrespective of duration, give very nearly a smooth curve, but the eastern lunes systematically show a slight preponderance over the western.

It is thus seen that the preponderance in area of the eastern hemisphere over the western, as shown in Table III., is one which is entirely confined to the classes of spots which have long duration. Table XII. brings this out yet more clearly, for it exhibits in tabular form the differences between the corresponding lunes east and west; the areas for each class being expressed as in Table XI., in thousandths of the total area of that class. It shows that in the long-lived groups there is a steady preponderance of the east over the west, not only for the two hemispheres of the Sun, but also for each pair of lunes. It shows also how, contrariwise, for the short-lived groups, the west preponderates still more emphatically over the east. Just the same result is obtained if the northern and southern hemispheres are treated separately, though the figures naturally show greater irregularities, since the numbers treated are smaller.

TABLE XII.

Differences between the Corresponding Lunes, E.–W., expressed in thousandths of Total Area for Whole Sun.

No. of Days.	1–14	2–13	3–12	4–11	5–10	6–9	7–8	E.–W.
14	+12	+ 24	+22	+20	+22	+15	+ 2	+116
13	+10	+ 12	+15	+16	+10	+ 6	+ 3	+ 72
12	+ 4	+ 14	+14	+10	+ 5	+ 3	+ 1	+ 50
11	+ 7	+ 7	− 2	+ 0	+ 3	+ 6	+ 3	+ 24
10	− 0	− 14	−19	−12	− 5	− 5	− 1	− 56
9	− 8	+ 3	− 7	− 1	− 1	+14	+ 8	+ 10
8	+ 6	− 2	−18	−29	−35	−30	−21	−130
7	+ 3	− 40	−61	−69	−69	−62	−28	−326
6	− 7	− 67	−77	−59	−60	−60	−18	−348
5	−37	−106	−96	−69	−44	−30	−14	−398
4	−39	− 91	−82	−60	−19	+ 6	+ 9	−276
3	−53	−107	−90	−42	− 3	−16	− 3	−314
2	−50	−174	−38	−22	−23	+22	− 3	−288
1	−54	− 55	+15	+13	− 7	+ 6	+22	− 60
Total,	+ 5	+ 3	+ 2	+ 3	+ 1	+ 1	+ 0	+ 14

What, then, can be the cause of this striking difference in the behaviour of groups of long duration and of short duration? Why should the former show their greatest areas in the eastern hemisphere, and the latter so markedly in the western?

The explanation is very simple. Three circumstances combine to bring it about.

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First, whilst groups observed for twelve, thirteen, or fourteen days are undoubtedly groups of long duration, groups observed for only three or four days are by no means necessarily of short duration. They may have existed in the unseen hemisphere before they came under observation, or they may have continued to exist there after they had passed beyond the range of observation. The time during which we observed them may in many cases represent simply the beginning or the close of the life-history of long-duration groups, so that the spots classed as of short duration must really include a great number of long duration.

Next, it has been already pointed out in Table IV., that the longer the life-history of a spot, the greater on the average will be its mean area.

Third, just exactly as the spotted area of the Sun increases much more quickly as the cycle runs up from minimum to maximum than it decreases when the cycle runs down from maximum to minimum, so is it with the great majority of individual spot groups—the growth in area is more rapid than is the decline. This characteristic we may denote by the term "spot phase."

7. *Analysis of the Spot Groups of* 8-*days apparent Duration.*

It follows, therefore, if we are dealing with one of the classes of short-duration spots, say, for example, with those of eight days, that beside the true 8-day spots, we have a number of spots really of long duration but classed as short because they formed in the invisible hemisphere, and only the last eight days of their existence were passed on this side of the Sun. Whilst these groups are under observation they are decaying, and their chief energy is already passed, so that their areas are not of a much higher order than those of true 8-day groups. The areas, therefore, in the eastern hemisphere will be but little affected. But it will not be so in the western hemisphere. Beside the true 8-day groups there will also be a number of long-duration groups just forming, and classed with them because observed for eight days before they passed to the other side of the Sun. Being spots of long duration they will on the average be of great mean area, and being observed during the period of rapid growth, their areas will be of quite a different order from those of the true 8-day groups with which they have been classified.

Tables XIII. and XIV. bring out this effect very clearly. In Table XIII., the 8-day groups, whether they genuinely existed for only eight days or simply appeared to do so, have been divided into three categories:—Eastern groups, that is to say, groups seen first close to the east limb, *i.e.* in the first or second lunes; Central groups, first seen in the third, fourth, or fifth lunes, and last seen in the tenth, eleventh, or twelfth lunes, thus clearly having their origin and dissolution in the visible hemisphere; and

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Western groups, those last seen close to the west limb, *i.e.* in the thirteenth or fourteenth lunes. The first category will, therefore, be largely made up of groups which formed in the unseen hemisphere, but dissipated on the visible disc. The last category will

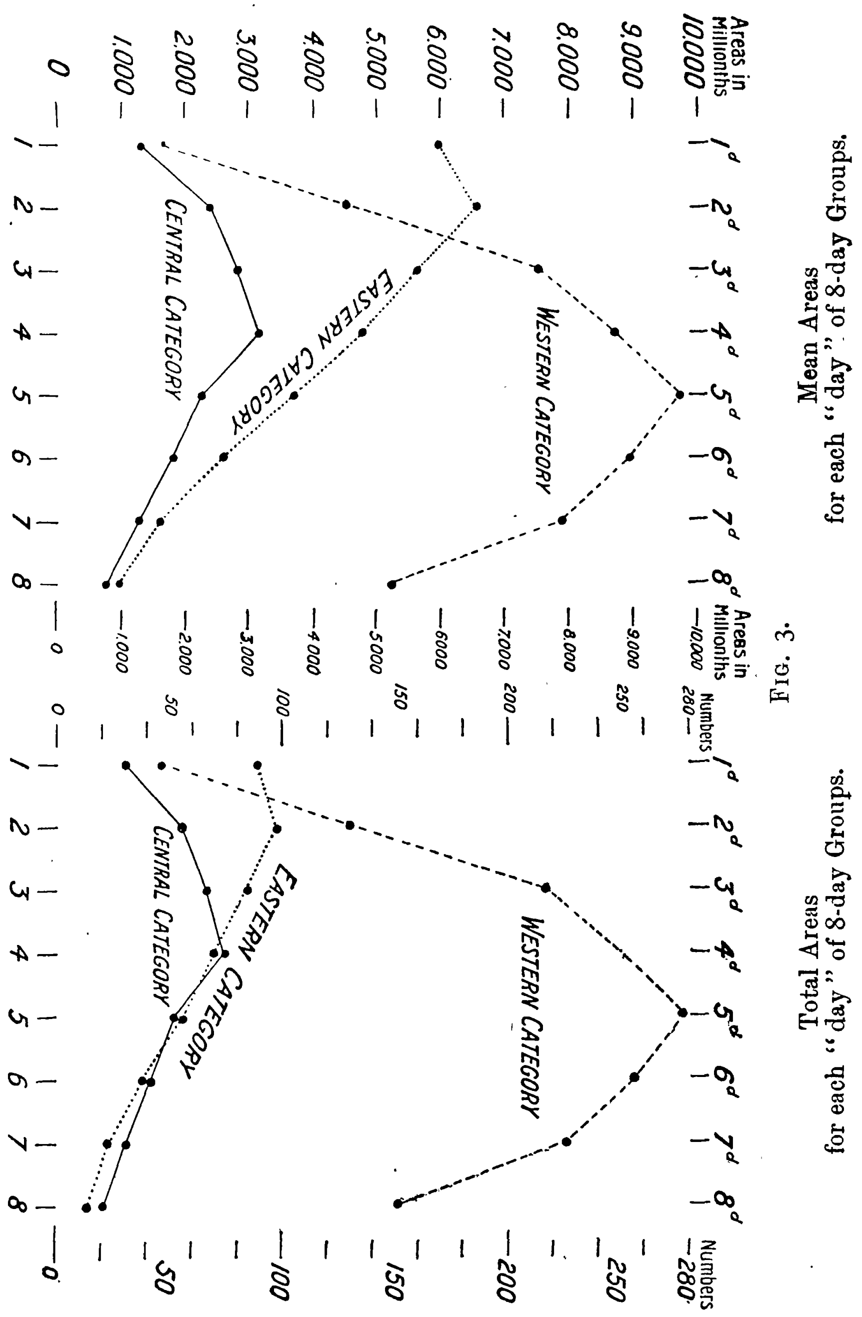

FIG. 3.

include many which, though they formed on the visible hemisphere, did not dissipate until after they had passed out of view at the west limb. Many therefore of both these classes are not true 8-day groups; they only appeared to be so, but really had a longer duration, and this would mean that on the average they were groups of greater area than true 8-day groups.

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TABLE XIII.

Total Areas for each Day of Life of Eastern, Western, and Central Groups of the 8-Day Spots, for Northern, Southern, and All Spots.

Class of Group.	1st Day.	2nd Day.	3rd Day.	4th Day.	5th Day.	6th Day.	7th Day.	8th Day.	Number of Groups.
				Northern.					
Eastern,	2587	2637	2085	1845	1409	1124	671	444	26
Western,	967	2593	3921	3916	4058	3606	3183	2832	14
Central,	725	1437	1296	1439	970	768	600	379	21
				Southern.					
Eastern,	3348	3908	3541	2933	2292	1495	941	541	41
Western,	691	1916	3635	4803	5666	5337	4723	2460	21
Central,	597	956	1531	1712	1309	1049	715	527	22
				All Spots.					
Eastern,	5935	6545	5626	4778	3701	2619	1612	985	67
Western,	1658	4509	7556	8719	9724	8943	7906	5292	35
Central,	1322	2393	2827	3151	2279	1817	1315	906	43

In the first place, it should be noted that the number of groups in the Eastern category is almost double the number of groups in the Western, and yet the total area in the Eastern is much less than in the Western, so that the mean area of an Eastern group is very much less than the mean area of a Western. These mean areas are given in Table XIV. Fig. 3 presents both Tables XIII. and XIV. in graphical form.

TABLE XIV.

Mean Area for each Day of Life of Eastern, Western, and Central Groups of the 8-Day Groups, for Northern, Southern, and All Spots.

Class of Group.	1st Day.	2nd Day.	3rd Day.	4th Day.	5th Day.	6th Day.	7th Day.	8th Day.
				Northern.				
Eastern,	100	101	80	71	54	43	26	17
Western,	69	185	280	280	290	258	227	202
Central,	35	68	62	69	46	37	29	18
				Southern.				
Eastern,	82	95	86	72	56	34	23	13
Western,	33	91	173	229	270	254	225	117
Central,	27	44	70	78	60	48	33	24
				All Spots.				
Eastern,	89	98	84	71	55	39	24	15
Western,	47	129	216	249	278	256	226	151
Central,	31	56	66	73	53	42	31	21

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The distinction between the "lunes," into which the visible disc of the Sun is divided, and the "days" in the life-history of a spot group, should be clearly borne in mind. The first *day* of the life of an Eastern group may fall in the first or in the second *lune*; its eighth *day* will fall in the eighth or ninth *lune*. The first *day* of a Central group may fall in the third, in the fourth, or in the fifth *lune*. The first *day* of a Western group may fall in the sixth or in the seventh *lune*. But in Tables XIII. and XIV. the areas for each day of the life of a group, in the several categories, are summed irrespective of the lunes in which they may actually fall; and since the first and the fourteenth lunes have really but half the area of any of the remaining twelve lunes, the areas of the *first day* of the Eastern category, and of the *eighth day* of the Western category, should be each multiplied by a factor greater than unity.

There is a very marked difference, not only in the total and mean areas of the three categories, but also in their several progressions. The Eastern category has a steady decay from the second day of its life—or indeed from its first day, if we allow for the fact that the first lune is smaller in area than other lunes,—and the eastern "day" has a greater area than the corresponding western "day"; the fourth day is greater than the fifth, the third than the sixth, etc. The Western category increases in area until its fifth day, after which it again steadily declines; and here it is the western "day" that is always greater than the corresponding eastern. In the Central category, the culmination is on the fourth day, and again the areas for the eastern "days" are greater than for the corresponding western.

And, considering the three categories, we find very strong evidence of the action of "spot phase." The groups of the Central category may take their rise over a range of the third, fourth, and fifth lunes; and as on the whole disc of the Sun there are 43 such groups, there is an average of 14 groups arising in each lune, the mean area of each group being 47. We may assume that this is the average number of true 8-day groups, arising in each lune all over the Sun, and that true 8-day groups average 47 in area. But we find, on comparing these numbers and mean area with those of the Eastern and Western categories, though these have but a range of one and a half lunes (half, that is to say, the range of the Central category), that these latter rank much greater both in numbers and mean areas. In both the Eastern and Western categories the true 8-day groups are swamped by the greater numbers and areas of the longer-lived groups classed as 8-day groups, because they are only *observed* for eight days in the visible hemisphere; the true 8-day groups seem to exercise little perceptible modification of the course run by either the Eastern or the Western category of groups.

The Eastern category must then be composed—overwhelmingly, both in numbers and areas—of the last eight days of decaying groups, and these final eight days show a steady decline. The Western category must be composed—overwhelmingly in areas, if not in the numbers of the groups—of the first eight days of active

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and long-lived groups, and must include in the mean their period of greatest activity, for the mean area culminates on the fifth day of their apparent life. Comparing the Eastern and Western categories, we find that the Eastern has very nearly double the number of spot groups of the Western, but that the Western has nearly double the total area and very nearly four times the mean area of the Eastern.

This detailed examination of the 8-day groups, therefore, renders two things clear. First, that for groups of this class—observed for eight days—many more come round at the east limb from the unseen hemisphere and die on the visible disc, than rise on the visible hemisphere and pass out of sight at the west limb.

Next, we have a clear explanation of the gradual shift of the maxima towards the west, as shown in Tables X. and XI. It is simply a function of "spot phase."

It is not possible to treat in the same manner groups that have a longer visible duration than 10 days. We cannot discriminate between those groups which existed for only from 12 to 14 days, and those which rose or dispersed in the unseen hemisphere. We should reasonably expect the former to be but a small fraction of the latter; but for them the influence of "spot phase" would be to throw the maximum somewhat to the east of the central meridian, since the rise of spot groups is more rapid on the average than their decline. But for groups that are observed as of shorter duration than 10 days, the curves in fig. 2 show the influence of the three categories of Eastern, Central, and Western. Already in the 6-day class, the preponderance in area and numbers of the Eastern category over the Central has produced a secondary maximum in the fourth lune, the greater maximum due to the Western falling in the twelfth. For the remaining classes, we see the effect of the Eastern categories in the swift run up in the early lunes, and subsequent decline. In the 2-day and 1-day spots, the central maximum is without doubt due to the better presentation there which enables small spots to be seen which might have been passed over altogether when foreshortened.

8. *Preponderance as to Area of the Eastern Hemisphere in Long-lived and Recurrent Groups.*

But there is a class of groups which must be free from any tendency of "spot phase" to link their greatest development with any particular lune. If we consider only those groups which have been seen in three or more distinct apparitions, and, rejecting the first and last, take only the intermediate appearances, then we are clearly dealing with the most stable portion of the life-history of the most permanent and important groups. We are not confusing together short-lived and unimportant groups with those which are greater and more durable, but are accidentally under observation for only a short time. Nor are we in any way introducing the condition that they must either take their rise or dissipate in any particular lune. In Table XV., therefore, I give for the northern hemisphere

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the total areas in each lune of the intermediate appearances of the groups which have been under observation, in three or more distinct rotations, the first and last appearances not being used. The total areas are also exhibited in the same table, for each lune, for all the 13- and 14-day groups in the northern hemisphere. It will be seen that there is an unfailing predominance of the eastern hemisphere over the western, but that the recurrent groups give a more regular curve than the 13- and 14-day groups. A comparison of the two sets of figures shows that there is a slight heaping up of areas in the central lunes for the 13- and 14-day groups as compared with the recurrent groups, which is due no doubt to the influence of "spot phase." But nevertheless, in both cases the predominance of the

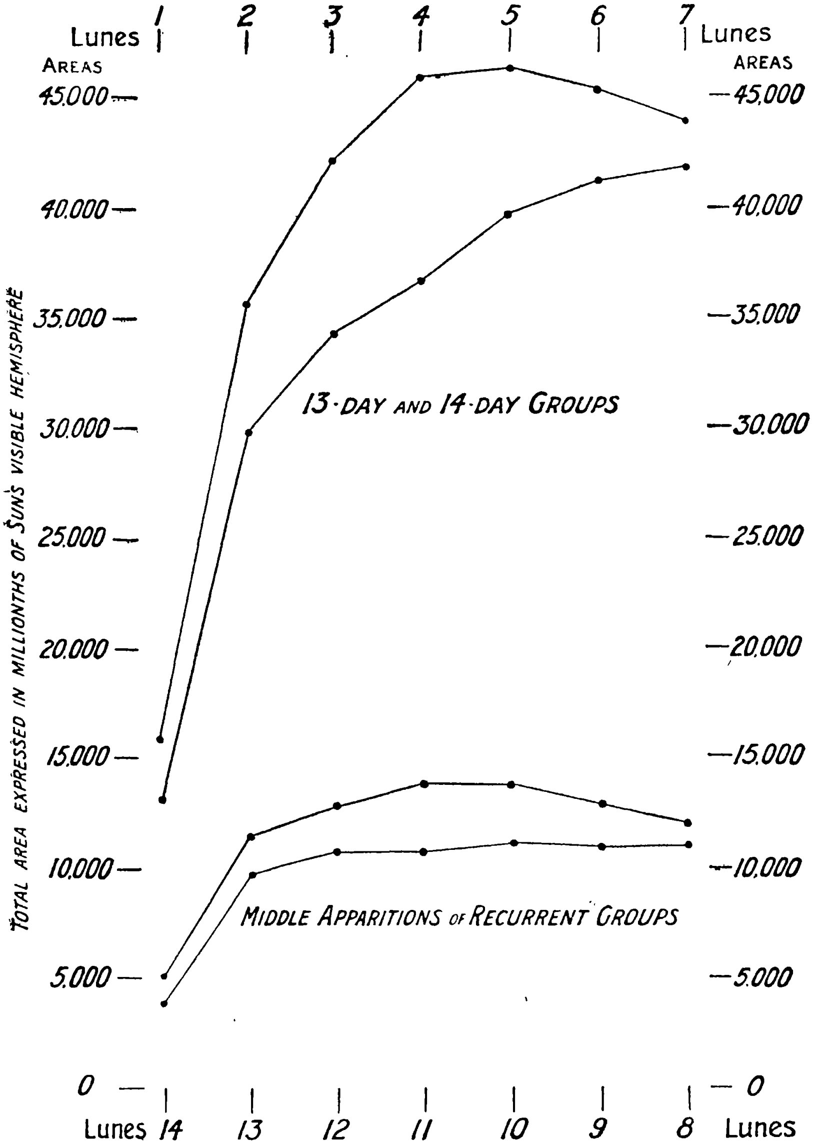

Fig. 4.—Total Areas for each Lune of long-duration and recurrent Groups.

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eastern areas over the western culminates in the central lune of each hemisphere. Fig. 4 represents Table XV. graphically.

TABLE XV.

Areas in each Lune of Middle Apparitions of Recurrent Groups in Northern Hemisphere.

Lunes.	1	2	3	4	5	6	7	East.
	14	13	12	11	10	9	8	West.
	5035	11401	12665	13800	13660	12934	12047	81542
	3824	9847	10815	10734	11092	11022	10953	68287
Diff. E. − W.	+1211	+1554	+1850	+3066	+2568	+1912	+1094	+13255

Areas in each Lune for all 13-*Day and* 14-*Day Groups in Northern Hemisphere from Table VII.*

	15677	35601	42280	45949	46129	45325	43888	274849
	13052	29913	34277	36616	39894	41311	41929	236992
Diff. E. − W.	+2625	+5688	+8003	+9333	+6235	+4014	+1959	+37857

9. *Summary.*

The foregoing tables show that there is a well-marked and steady preponderance of the eastern half of the Sun's disc over the western half, both as to the areas of the spots and as to the numbers of the separate groups. This excess in area of the eastern hemisphere over the western amounts to 17 per cent. for spots observed consecutively for 13 or 14 days; to more than 19 per cent. for recurrent spots during their time of greatest stability; and to 3 per cent. for the totality of areas of spots of all sizes and durations. As to the numbers of groups, the excess of the eastern hemisphere is 10 per cent. for ephemeral spots; is more than 9 per cent. if the groups are summed up as seen in the different lunes; and is 22 per cent. if we compare the groups seen in the two lunes nearest to the east limb with those seen in the two lunes nearest to the west limb. This last relation is the most striking which the inquiry has brought out. No fewer than 947 groups came into view round the east limb, or formed close to it, whilst only 777 disappeared round the west limb, or dissolved close to it. So that the difference of 170, or 22 per cent. of the number of disappearances, must be laid to the account of some influence exercised by the Earth. And these disproportions either in area or in number cannot be put down to any cause connected with the history or growth of the spots themselves, or to any solar cause whatever. East is east, and west is west, solely from an earthly point of view. From a solar standpoint, the "east limb," "central meridian," and "west limb" are purely conventional lines behind which every portion of the Sun's surface moves; they are not fixed landmarks upon the Sun. The

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cause of the disproportion must then be terrestrial, and terrestrial only.

It must be terrestrial only, but it may also be apparent only, being due in some way or other to an effect of presentation.

Some error must creep in from the effect of foreshortening. Foreshortening pure and simple is, of course, corrected for in the ordinary process of reduction, but it is probable that a few minute corrections may be further required on grounds already alluded to. Further, some spots, large enough to be seen and measured when near the centre of the disc, will wholly escape notice if they happen to be near the limb. Thus foreshortening may affect to some slight degree not only the areas, but also the numbers of the spot groups.

But, from the nature of the case, the effect of foreshortening must be symmetrical, with respect to the central meridian, and no systematic difference between the eastern and western hemispheres can arise from this cause. "Spot phase" (as has been already shown) has a distinct asymmetrical effect, when the spots of any particular class are considered by themselves; but when the totality of all spots is considered, this asymmetrical effect must go out, since (unless we admit that the Earth has a real effect upon the Sun) it is not possible that any particular phase in the life-history of a spot should be associated with any particular meridian of the Sun as seen from the Earth.

It does not appear, therefore, that it can be a mere effect of presentation.

I have called this paper, therefore, "An *Apparent* Influence of the Earth on the Numbers and Areas of Sun-spots," because it is quite conceivable that there may be some physical characteristic of sun-spots, purely solar in its nature, which renders them more easily visible when they are approaching us than when they are receding. Thus if we suppose that sun-spots are holes in the photosphere of which the axes are generally sloped downward from west to east, or if we suppose that there is a great heaping up of the surface behind a sun-spot, we might have some explanation of the predominance of the eastern hemisphere both in the numbers and areas of sun-spots. Neither of these suggestions would, in my opinion, account for the relations which I have put in evidence, and there is another class of phenomenon which seems to show the same predominance of the eastern hemisphere over the western which could hardly be affected in the same way.

10. *Preponderance of the Numbers of Prominences in the Eastern Hemisphere.*

I had completed the foregoing statistics when it occurred to me to ascertain whether prominences were more frequently observed on the east or on the west limb, and in making this supplemental inquiry I came across a note by M. Sykora in the *Memorie della Società degli Spettroscopisti Italiani* for 1897, p. 161, in which he drew attention to the circumstance that there was a

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slight but unmistakable predominance of eastern prominences. I carried on the summation of the prominences as given from the Catania Observatory in Sicily to the end of 1905, and found that from 1892–1900 inclusive the eastern hemisphere was the more prolific in every year. The tables were turned, however, with the year of minimum, 1901, and for four years the west was slightly the more favoured. In 1905 the east again predominated. It will be seen, therefore, that for the period with which my paper is concerned, namely, the cycle 1889–1901, the prominences showed the same feature as the sun-spots; and it seems very difficult to suggest any function of presentation, either connected with the solar constitution or with the conditions of observation, which would affect both phenomena in the same way. Table XVI. and fig. 5 exhibit the comparison of the numbers of prominences observed on the east and west limbs at the Catania Observatory.

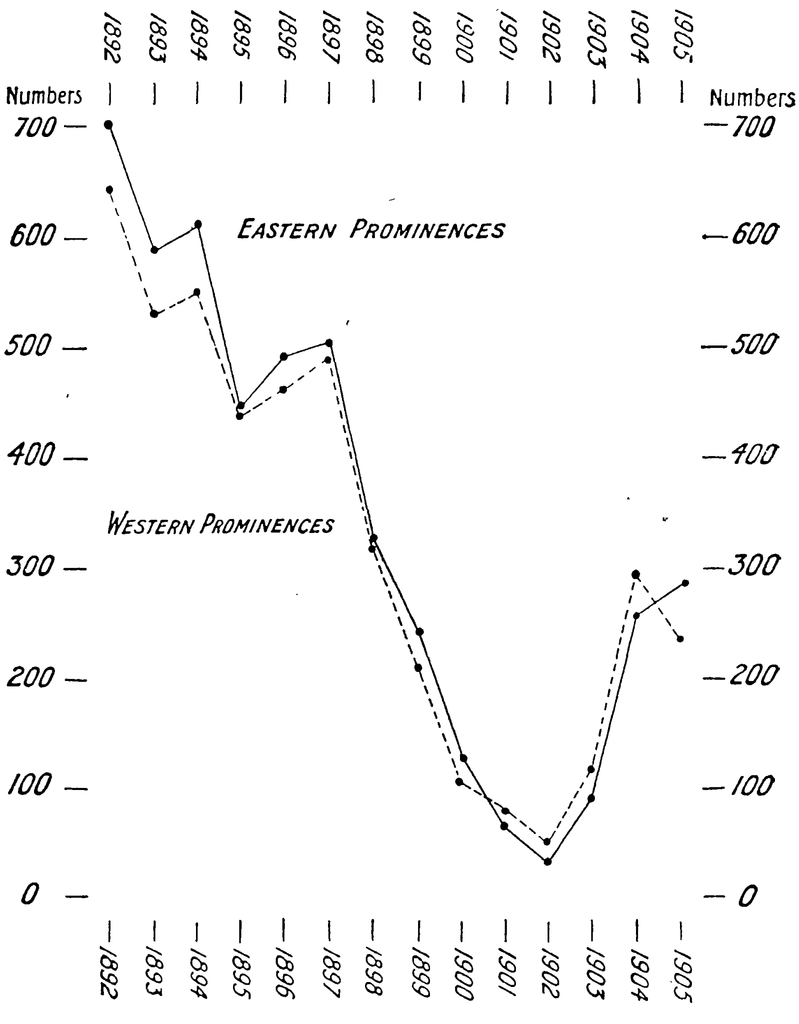

Fig. 5.—Numbers of Prominences as observed in different Years on the East and West limbs of the Sun at the Royal Observatory, Catania.

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TABLE XVI.

Prominences observed at Catania in Sicily.

Year.	E.	W.	Total.	E.-W.
1892	700	641	1341	+ 59
1893	589	530	1119	+ 59
1894	613	552	1165	+ 61
1895	446	439	885	+ 7
1896	491	462	953	+ 29
1897	504	493	997	+ 11
1898	324	319	643	+ 5
1899	242	213	455	+ 29
1900	134	107	241	+ 27
1901	64	80	144	− 16
1902	33	49	82	− 16
1903	91	118	209	− 27
1904	256	295	551	− 39
1905	282	238	520	+ 44
Total,	4769	4536	9305	+ 233

The results to which I have come in the foregoing paper are not what I expected to find when I began this inquiry. Indeed, they are the very opposite of what has been supposed would be the result of planetary action, if it had any effect on the solar disturbances. It has been usually assumed that if a planet had any influence upon the Sun, it would be in the nature of spot production, not spot extinction. But the evidence of the foregoing tables seems to show that spots tend to diminish in area rather than to increase as they pass under the Earth, and that there is a decided tendency to check the generation of spots on the hemisphere presented to the Earth.

11. *Preponderance in Spotted Area at Apogee.*

I have no speculations to offer as to the nature of this terrestrial influence upon the solar spot groups. Were it in any way analogous to a tidal effect, we might expect to find some slight difference in the mean spotted area of the Sun in perigee and in apogee. In Table XVII., therefore, I have given the mean daily spotted area per month for two periods of eleven years each, namely, 1880–1890 and 1891–1901, and also for the twenty-two years taken together. The area in each month of any year has been expressed in thousandths of the sum of the twelve monthly mean areas for that year. On the whole, the summer months, when the Earth is most distant from the Sun, show the larger spotted area; May to August giving a mean of 86, whilst November to February give a mean of 79. There are, however, big

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irregularities, as the comparatively short period of twenty-two years is insufficient to eliminate accidental irregularities.

Table XVII.

Mean Daily Spotted Area per Month, expressed in thousandths of the Total Area, for the Periods 1880–1890, 1891–1901, *and* 1880–1901.

Period.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1880–1890	74	76	78	95	84	89	93	73	89	89	93	67
1891–1901	87	93	67	75	84	88	93	95	96	78	62	82
1880–1901	81	85	72	84	84	89	93	85	93	83	76	75

This table I drew up several years ago, but it seemed to me so contrary to what one would naturally expect, that the spotted area should be greatest at apogee, that I did not then pursue the inquiry further. But in the light of the statistics that I have given in this present paper, it suggests that the inquiry is well worth pursuing with regard to the other planets.

The Earth is of such insignificant size, not merely as compared with the Sun, but even as compared with very many individual sun-spots, that its influence (if any such exists) on their number and size might well have been expected to be imperceptible. I commenced this investigation fully expecting to obtain a purely negative result; I was certainly not prepared to find that the effects of the Earth's apparent influence (of whatever nature this may be), would be so great, so striking, so consistent, and seen in so many directions.

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1907 *May* 6.

Appendix added 1907 *May* 28.

It has been suggested to me that I might supplement the above tables by some statistics as to the numbers of groups that are born or die on the visible or invisible hemisphere respectively. This is done in Table XVIII., in which each group has been counted only once, no matter in how many rotations it has been seen. In other words, the numbers have been corrected for the recurrence of long-lived groups.

Table XVIII.

Born and dying on Visible Hemisphere.	N.	S.	Whole Disc.
Short-lived groups	700	829	1529
Groups seen in more than one apparition .	39	55	94
Total . .	739	884	1623

Table XVIII.—*continued.*

	N.	S.	Whole Disc.
Born on Visible and dying on Invisible Hemisphere.			
Groups seen only in one apparition . .	107	129	236
Groups seen in more than one apparition .	25	39	64
Total . .	132	168	300
Born on Invisible and dying on Visible Hemisphere.			
Groups seen only in one apparition . .	166	225	391
Groups seen in more than one apparition .	43	36	79
Total . .	209	261	470
Born and dying on Invisible Hemisphere.			
Groups seen only in one apparition . .	28	31	59
Groups seen in more than one apparition .	21	22	43
Total . .	49	53	102
Grand Total . .	1129	1366	2495
Groups seen twice	128	152	280
Groups seen three or more times . . .	43	52	95
Total . .	1300	1570	2870

Neglecting therefore the short-lived spots that are born and die on the visible hemisphere of the Sun, we find

Table XIX.

	N.	S.	Whole Disc.
Born on visible hemisphere	171	223	394
,, invisible ,,	258	314	572
Dying on visible ,,	248	316	564
,, invisible ,,	181	221	402